STUDY OF TIME LAPSE PROCESSING FOR DYNAMIC HYDROLOGIC CONDITIONS

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TYPE I PROGRESS REPORT

A) Title: STUDY OF TIME-LAPSE DATA PROCESSING FOR DYNAMIC HYDROLOGIC CONDITIONS

ERTS-A PROPOSAL 342-B

B) GSFC ID PR154

C) Problems Impeding Progress - None

D) Accomplishments

(I) During Reporting Period

(a) Equipment

Design of the semiconductor scratchpad memory (for revisable thematic masks) is nearing completion and construction will start during the next period. Several changes in the operating controls of the ESIAC have been made to improve the operating efficiency. A significant example is the recent addition of a capability for storing the gray scale and annotation block from an ERTS frame during the vertical retrace interval of the television signal. Thus when the main image area is being used to display a magnified (zoomed in) segment from a full frame, the pertinent radiometric calibration data for the frame--at zero zoom--is still available (by "rolling" the image vertically to display the normal vertical blanking interval). Any gain, dc offset, or amplitude compression experienced by the main signal during the storage and reproduction process is also experienced by the calibration waveform.

A source of some annoyance, to-date, has been the experience that color slides made from the TV color display have not faithfully reproduced the colors originally set up on that display. The reds, in particular, have lacked brilliance. Attempts are currently under way to improve the reproduction through judicious alteration of film/filter/exposure combinations, or possibly by electronic masking.

(b) Data Measurements

1) For Dr. Mark F. Meier (IN045) U.S. Geological Survey, Tacoma, Washington: Areal snow measurements of Mt. Rainier were made from the data series 29 July, 16 Aug, 2 Sept, 8 Oct, 14 Nov, 2 Dec, 1972, plus 6 Jan, 25 Jan and 11 Feb 1973.* In addition to Mt. Rainier, snow cover measurements were made for the following basins and dates:

Basin 1755 - 29 July, 2 Sept and 8 Oct 1972

Basin 1825 - 29 July, 2 Sept and 8 Oct 1972

Basin 1413 + 1420 - 2 Sept, 8 Oct and 14 Nov 1972

Basin 1434 - 2 Sept, 8 Oct and 14 Nov 1972

Basin 1330 - 2 Sept, 8 Oct and 14 Nov 1972

We are continuously seeking to improve our techniques and understanding of the entire process of obtaining snow measurements on the ESIAC (Electronic Satellite Image Analysis Console). For each data set measured we are currently using the procedure of constructing curves relating pixel count (which can be converted to areal snow cover) above a given threshold to gray scale steps for each MSS band used. Figure 1 illustrates such curves for the Mt. Rainier scene on 11 February 1973. The abscissa is in gray scale steps. The left hand ordinate is in pixels/2 and the right hand ordinate is area (in kilometers square) above threshold. On the example presented, it is obvious from the slope of the curve that the change in area is smallest in gray scale steps 6, 7, and 8 and increases as one progresses to gray scale steps below 6. This is true both for MSS band 5 and band 6. Consequently the procedure is sensitive to the "slicing level" used.

The "best visual estimate" of the amount of snow in the image is obtained by setting the thresholder on ESIAC to equal the areal coverage of the snow and determining the number of pixels from the

*Imagery for 20 Sept and 20 Dec 1972 were not available and the imagery of 26 Oct 1972 was too cloudy to permit an areal measurement.

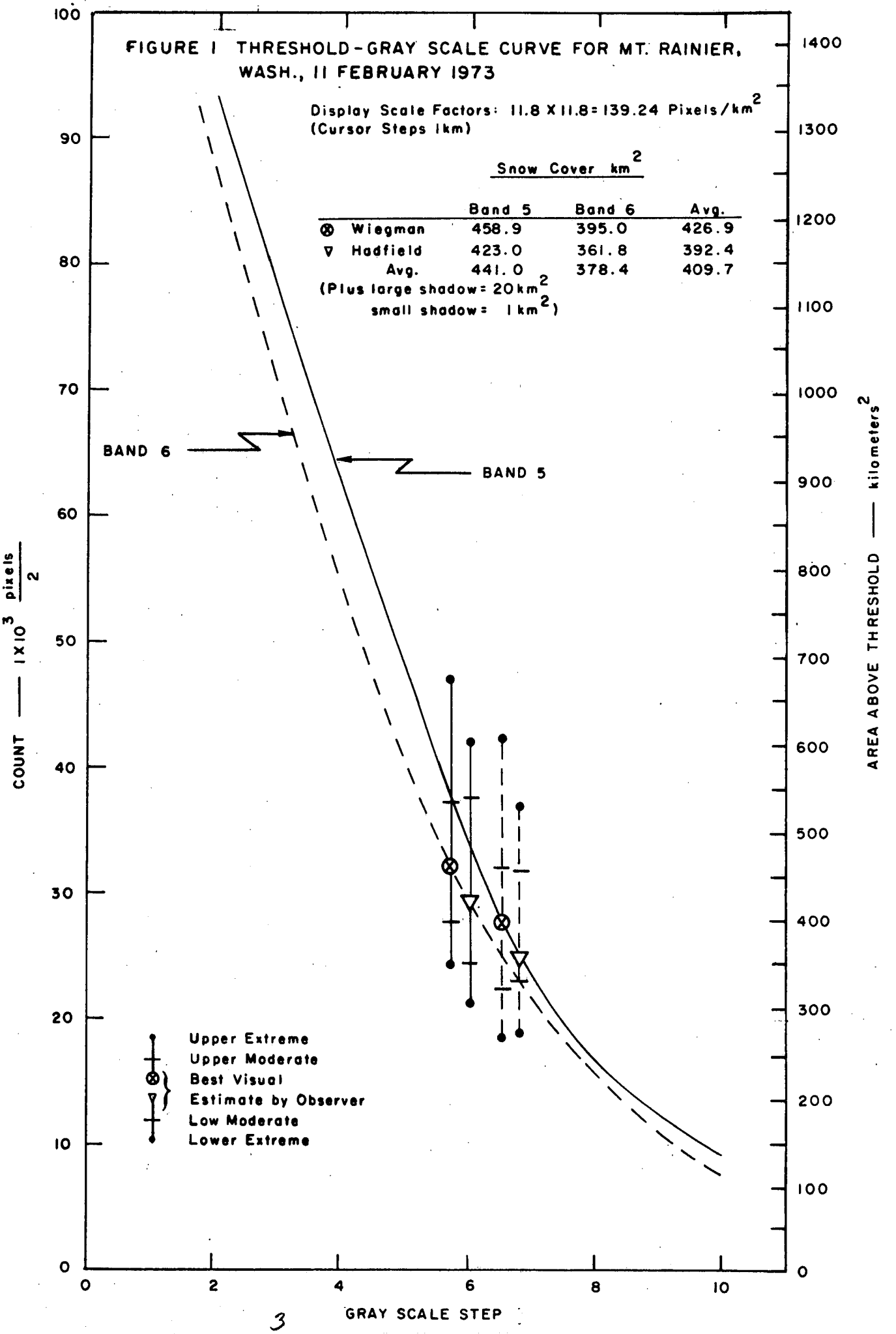


FIGURE 1 THRESHOLD-GRAY SCALE CURVE FOR MT. RAINIER, WASH., 11 FEBRUARY 1973
Display Scale Factors: 11.8 X 11.8 = 139.24 Pixels/km²
(Cursor Steps 1km)
Snow Cover km²
Band 5 Band 6 Avg.
⊗ Wiegman 458.9 395.0 426.9
▽ Hadfield 423.0 361.8 392.4
Avg. 441.0 378.4 409.7
(Plus large shadow = 20km²
small shadow = 1km²)
BAND 6
BAND 5
Upper Extreme
Upper Moderate
Best Visual
Estimate by Observer
Low Moderate
Lower Extreme
COUNT — 1X10³ pixels/2
AREA ABOVE THRESHOLD — kilometers²
GRAY SCALE STEP
0 2 4 6 8 10
0 10 20 30 40 50 60 70 80 90 100
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400

digital counter. This value is entered on the curve. Four other estimates (i.e., an estimate of an extreme low value above which snow must certainly exist; a low moderate value, an upper "moderate" value and an extreme high value, which probably includes other than snow) are also obtained. These estimates are obtained independently by two operators. It is very encouraging that this procedure yields best visual estimates and ranges that are fairly consistent. In this example, in both bands 5 and 6 the distance to the lower extremes from the best visual estimate is about half of the departure to the upper extremes. This has been true, generally, for all the data evaluated to date.

The slopes of the curves (which express area above thresholds for gray scale steps) vary with season, (due to changes in sun angle and amount of snow present). The curves for Mt. Rainier in Figure 2 illustrate these variations. However, to date, about 75% of the best visual estimates on band 5 fell between gray steps 5.5 to 6.5 and all estimates were between the range 4.8 - 6.8.

Acting on a suggestion by Mr. Robert Krimmel of Dr. Meiers staff, we are also experimenting with a date-to-date differencing technique for obtaining snow measurements.

An example of the date-to-date differencing technique is illustrated in Figure 3. Image A shows the snow cover on Mt. Rainier, Washington, as imaged in MSS band 5 on 8 October, when the snow pack was near its yearly minimum. Image B taken on 14 November shows the addition of new snow.* Image C is a TV display of the result of subtracting the video signal for 8 October from the video signal of 14 November. With this procedure those areas where there has been no

*The black patch at left center in each image is the shadow of a steep cliff near the summit. The size is much larger on 14 November, when the sun is lower, than on 8 October. In both cases the shadowed areas are well above the snow elevation, and probably are fully snow-covered.

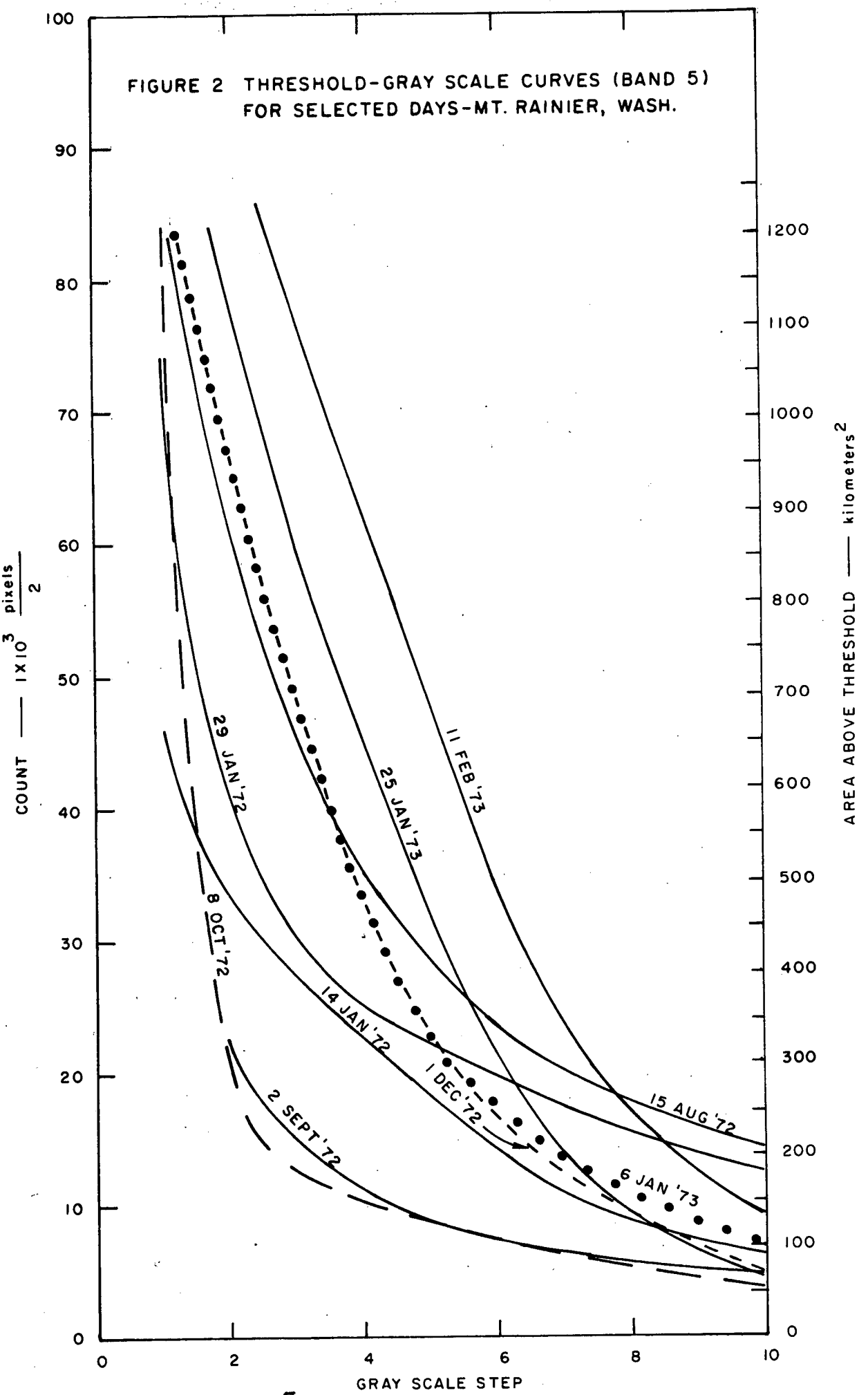
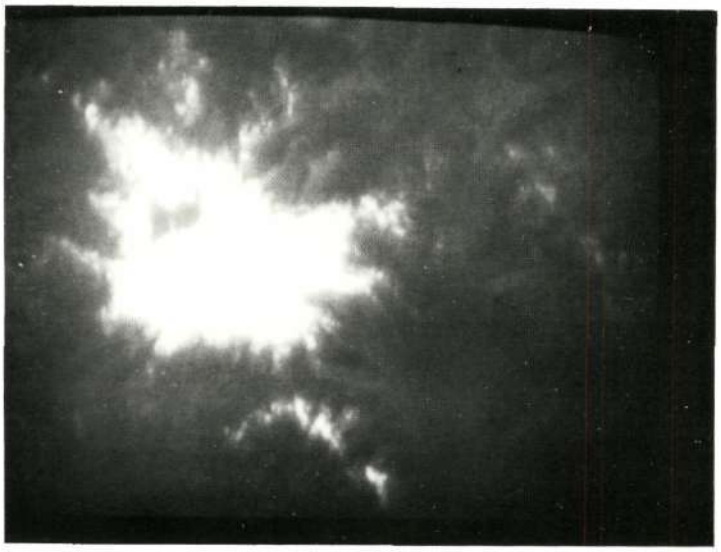
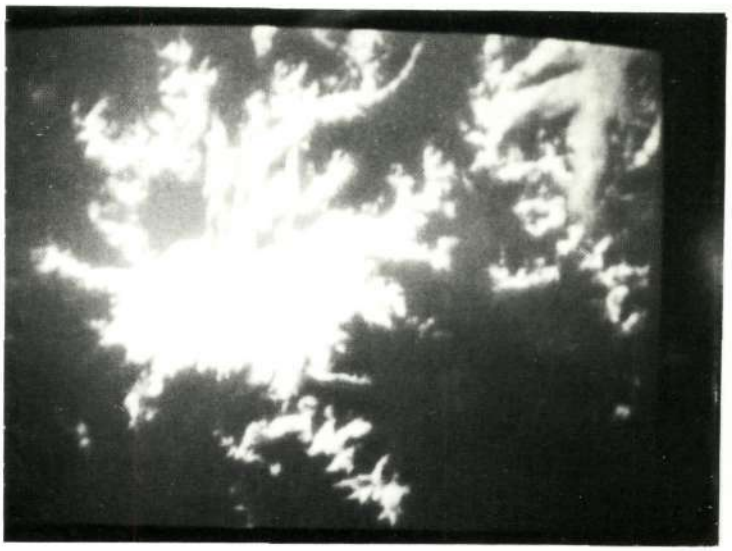


FIGURE 2 THRESHOLD-GRAY SCALE CURVES (BAND 5)
FOR SELECTED DAYS-MT. RAINIER, WASH.
COUNT — $1 \times 10^3 \frac{\text{pixels}}{2}$
AREA ABOVE THRESHOLD — kilometers^2
GRAY SCALE STEP
0
2
4
6
8
10
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
11 FEB '73
25 JAN '73
29 JAN '72
8 OCT '72
14 JAN '72
1 DEC '72
15 AUG '72
6 JAN '73
2 SEPT '72

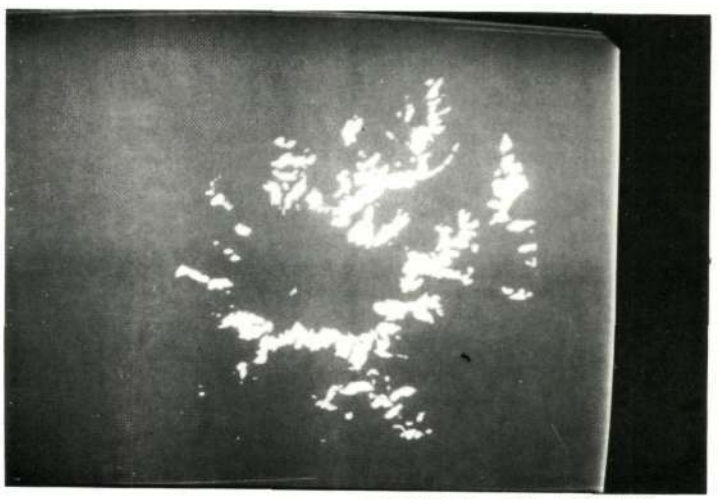


(a) MT RAINIER, WASH. 8 OCTOBER 1972
1077-18-260-5

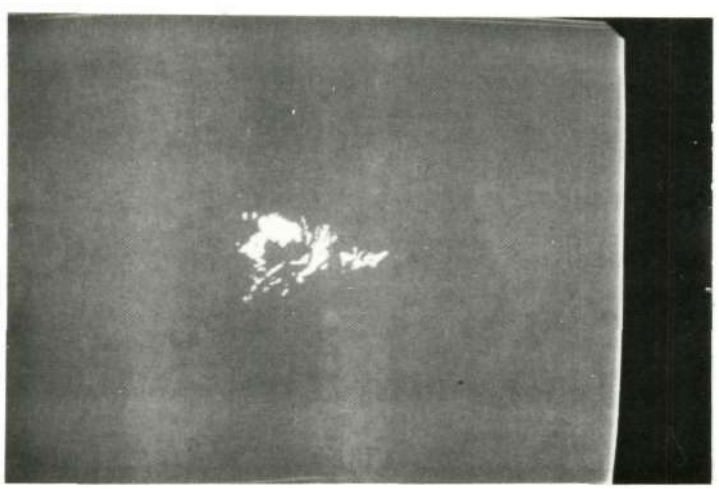


(b) MT RAINIER, WASH 14 NOVEMBER 1972
1114-18-322-5

(c) CONTINOUS TONE DISPLAY OF DATE TO DATE IMAGE DIFFERENCING (MSS-5) 14 NOVEMBER-8 OCTOBER 1972



(d) 14 NOVEMBER-8 OCTOBER 1972 BINARY MASKS OF WHITE REGIONS OF FIG. C



(e) 8 OCTOBER-14 NOVEMBER 1972 BINARY MASKS OF BLACK REGIONS OF FIG. C

FIGURE 3 DATE TO DATE DIFFERENCING TECHNIQUE

significant radiance change cancel to a mid-gray appearance, regardless of whether the original scene content had been bright or dark. Anything whiter than the mid-gray level in Image C results from a higher radiance on 14 November than on 8 October. This whiteness is interpreted as being new snow (or cloud), with the brightest regions representing the greatest radiance change. Conversely, the dark-gray-to-black regions of Image 3C indicate regions where the radiance had decreased significantly during the 37 day period. In this season, such radiance decreases are largely due to lower sun angle and increased shadowing, and most probably do not indicate decreases in snow.

Images D and E of Figure 3 show binary masks derived by "slicing" (thresholding) the difference signal of Image C to quantify the predominantly black areas. The white or "true"regions of each mask is then measured separately by a digital counter. For this case, only the snowpack increase (Image C) was counted.

As with the procedure for measuring areas on each given date, this technique also shows the need for some subjective judgment in interpretation but it is possible that measuring differences directly may yield more representative values than obtaining differences by subtracting the measurements of snow made on two different dates. At any rate, difference values have been obtained for six dates and forwarded to Dr. Meier and Mr. Krimmel for their perusal. An evaluation of this method is continuing.

2) For Dr. Raymond M. Turner (IN-411) U.S. Geological Survey, Tuscon, Arizona: Due to the location of his test sites, Dr. Turner has now accumulated the largest file of sequential imagery, some 14 cycles of usable data, of any of our investigators. Systematic changes in areal extent of the vegetated regions are clearly visible while watching the time-lapse replays of these sequence in color. While

this is an encouraging first step, a principal objective of Dr. Turner's research is the mapping, or quantitative documentation of these areas. Consequently, we have been investigating various methods of creating binary thematic masks (thresholdings) which appear representative of the scenes observed visually and at the same time be amenable to measurement.* Because much of the vegetative cover is quite sparse the documentation method ideally should reflect some measure of the density of vegetation coverage as well as areal extent and location. A method of amplitude thresholding on the MSS 6 minus MSS 5 difference waveform at several calibrated levels appears quite promising, and initial copy samples have been sent to Dr. Turner. Refinements in both equipment and procedure are continuing, in preparation for Dr. Turner's planned visit to SRI during the week of 14 May.

3) For Dr. E. J. Pluhowski (IN 058) U.S.G.S. W.R.D. Arlington, Va.: Dr. Pluhowski visited SRI on March 20-22, 1973, bringing with him all available cloud-free 70mm color separation transparencies for the Lake Ontario area through January, 1973. ESIAC was used to enhance and display sediment plumes for the following estuaries:

1. Port Dalhousie Harbor
2. Welland Canal
3. Genesee River

Additionally, several examples of shoreline erosion were detected in the imagery, especially in frame 1137-15355. The Niagara River plume was not directly distinguishable. Under certain conditions, however, its boundaries could be inferred. Surprisingly, the Niagara River usually appeared less turbid than the ambient lake water so that its signature was difficult to discern.

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*Also, such results ideally will be useful as map overlays, and not be too complicated for reproduction in publications.

4) For Dr. Este F. Hollyday (I.N. 389) U.S. Geological Survey, W.R.D., Nashville, Tenn.: Dr. Hollyday visited SRI on April 3, 4 and 5. Virtually all of the time was devoted to working with ESIAC to display imagery brought by him. The basic objective was to determine the degree to which ESIAC could be used in enhancing, identifying, and mapping the following four major categories or "themes":

Healthy vegetation

Exposed water surface

Snow

Massed works of man

These data, carefully partitioned geographically into specific drainage basins, are needed as time-dependent input to multiple regression equation linking stream flow with these and other measurable characteristics.

As relatively little repetitive data was yet available for time lapse analysis, most of the time was spent studying single-band and multi-band enhancements at various scales of various regions in the Delaware-Chesapeake Bay region for fall and early winter. Color photographs were made of enhanced imagery and trial binary thematic masks were made by amplitude thresholding single band signals within specific drainage basins. These were compared with similar theme extractions which had been made manually.

5) For Dr. C. G. Reeves (U.N. 168) Texas Tech University, Lubbock, Texas: Census of the playa lakes (3405) in the area designated by Dr. Reeves was made using

ERTS Frames: 1007-16572, 16575 and 16581
1078-16516, 16522 and 16531
1098-17041

II Planned for Next Reporting Period

Continued data processing and reporting for Drs. M. F. Meier and R. M. Turner.

Initial data processing for Mr. A. E. Higer, U.S.G.S. (W.R.D.) Miami, Florida and Mr. C. E. Coker, U.S.G.S. (W.R.D.), Tampa Florida.

Further, we plan to continue and probably complete the additions to the equipment mentioned earlier in this report.